DEPARTMENT OF THE INTERIOR, CANADA
Hon. Frank Oliver, Minister; W. W. Cory, Deputy Minister
Forestry Branch, R. H. Campbell, Superintendent.

IRRIGATION SERIES
BULLETIN No. 1.

IRRIGATION

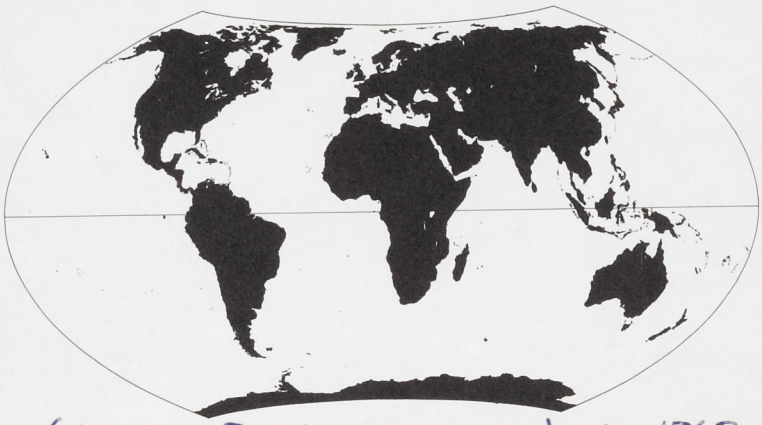
IN

SASKATCHEWAN AND ALBERTA

COMPRISING A SYNOPSIS OF THE IRRIGATION ACT AND IRRIGATION PRACTICE

OTTAWA
GOVERNMENT PRINTING BUREAU
1910

5977—1



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IRRIGATION PRACTICE.

PART I.—THE IRRIGATION ACT GOVERNING THE ADMINISTRATION OF IRRIGATION IN SASKATCHEWAN AND ALBERTA.

Irrigation has been practised to some slight extent in the southern portions of what are now the provinces of Alberta and Saskatchewan ever since these districts were first settled, but the irrigated tracts were of small extent and the works were crude, usually consisting merely of a makeshift dam and headgate and a ditch for the irrigation of a few acres of garden or hay land in connection with cattle raising, which was practically the only occupation of the earlier settlers.

There was at this time no law regulating the use of water for irrigation and he who wished took from the nearest stream what he required, or thought he required, without permission and without making any record of the quantity taken. As settlement advanced the attention of the government was drawn to the confusion that was certain to result as this practice became more general, and steps were taken to frame an irrigation code adapted to the needs of the country. Officers of the Topographical Survey Branch of the Department of the Interior were assigned to the work and, as a result of their investigations, a Bill was introduced at the session of parliament in 1893, but was not pressed to a vote at that session. In the following year, opportunity having in the meantime been given for further investigation, the Bill was re-introduced and passed under the title of 'The Northwest Irrigation Act.' This law has since been amended from time to time in such manner as experience has shown to be necessary, but, in its essential features, it stands to-day substantially as when first enacted.

Plan of Administration.

The plan of administration decided upon included the following:—

(*a*) The providing of such information regarding the contour of the country, the source and quantity of the water supply and the possible and proper distribution of the same as would enable the government to exercise that control and supervision of its use in irrigation which is so necessary to prevent disputes and establish the undertaking on a permanent and sound basis.

(*b*) The determination of the topography and elevations with reference to the land survey system and the establishment of permanent points of reference regarding them, so that the information procured may be available for use by surveyors and engineers as a basis for their detailed surveys for canals and reservoirs.

(*c*) The location and segregation of suitable sites for reservoirs and providing the information needed by the government in dealing with such sites.

(*d*) The issue of such plans as would enable all irrigation surveys to be referred to common and well-established landmarks and a common datum for elevations so that each private survey, based upon the framework provided by the government plans, may become a part of the whole, and in time permit of the publication of an accurate topographical map of the whole irrigation district.

Synopsis of Irrigation Act.

The present law is believed to embody such of the best principles of the irrigation laws of other countries as are applicable to local conditions in western Canada, and to be free from most of the defects of those laws. The Irrigation Act applies 'to the

provinces of Saskatchewan and Alberta and to the Northwest Territories, except the provisional districts of Mackenzie, Franklin and Ungava.'* Its essential features are:

I. That the water in all streams, lakes, springs, ponds or other *surface* sources of water supply is the property of the Dominion government.‡

II. That the right to use this water may be obtained by companies or individuals upon compliance with the provisions of the law.

III. That the uses for which water rights may be so acquired are:

(*a*) *Domestic,* which includes household and sanitary purposes and all purposes connected with the watering of stock and the operation of agricultural machinery by steam.

(*b*) *Industrial, i.e.,* the operation of railways and factories by steam.

(*c*) *Irrigation,* and

(*d*) *Other purposes* than those above-mentioned.

IV. That the individual or company acquiring such a water right shall be given a clear and indisputable title to the right to the use of the water so long as he shall continue to apply it to beneficial use.

V. That such rights may be forfeited by abandonment, waste or non-use.

VI. That holders of water rights shall have the protection and assistance of permanent government officials in the exercise thereof and that all disputes and complaints in connection therewith shall be referred to and settled by such officials, whose decisions shall be final.

PROCEDURE FOR ACQUIREMENT OF WATER RIGHTS.

PRELIMINARY SURVEYS.

A person who desires to acquire a right to use water for any of the purposes previously mentioned should apply to the Commissioner of Irrigation† at Calgary, Alberta, giving a general description of his proposed undertakings. Upon payment of a fee of $3 the commissioner is authorized to issue a license permitting the applicant to enter upon public or private lands for the purpose of making the necessary surveys, provided that no unnecessary damage shall be done.

FILING OF PLANS.

Having completed his surveys and finally decided upon his project he should next file with the Commissioner—

(*a*) A memorial containing full information as to the location, character and estimated cost of the works, the location and character of the land to be irrigated and, if water is to be supplied to others, the terms and price to be charged. Sufficient information should also be furnished to permit the Commissioner to judge of the applicant's financial ability to carry out the project.

(*b*) A general plan of the proposed project.

(*c*) Detail plans of the necessary structures in connection with the undertaking.

Such memorials and plans shall be open for examination by the public at all times in the Department of the Interior and in the office of the Commissioner of Irrigation.

PUBLICATION OF NOTICE.

The application may be refused by the Commissioner if it does not comply with the provisions of the law, if after inspection it appears that the project is impracticable

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* R.S.C., 1906, c. 61, s. 4.

‡ The land within the territory to which the Irrigation Act applies is also the property of the Dominion.

† The offices of 'Commissioner of Irrigation,' and 'Chief Engineer' are at present combined.

from an engineering standpoint, or if the records show that there is not enough water available for the purpose. If, however, the application be approved, it is recorded against the stream or other source from which the water is to be drawn and the applicant is instructed to give public notice of his application by publication in five weekly issues of a local newspaper named by the Commissioner. A copy of each issue of such paper should be forwarded by the applicant to the Commissoner for record in his office.

The object of publication is that all interested persons may be informed of the application and given an opportunity of protesting against it if they believe it injuriously affects their interests. If protests are received they are carefully inquired into and, if ascertained to be well-founded, the application is either refused or so amended as to remove the cause of complaint.

AUTHORIZATION FOR CONSTRUCTION OF WORKS.

In case no protests have been filed, or after the satisfactory disposal of such as may have been filed, the Commissioner issues a certificate to the effect that the applicant has complied with the provisions of the law and at the same time he recommends the issue of authorization for the construction of the works, specifying the length of time he considers necessary for the purpose. The form of authorization issued to the applicant permits him to construct the works as shown by the memorial and plans filed by him and fixes the time within which they are to be completed, but provides that right of way shall be obtained by the applicant before the works are constructed across any lands not owned or controlled by him.

POWER TO EXPROPRIATE LAND.

The form of authorization for the construction of works empowers the applicant to expropriate any public or private lands necessary for his purpose. Permission must, however, be obtained from the provincial, municipal or other authorities having control over any public highway or road-allowance for the construction of the works across such, and, in the event of such consent not being obtained, provision is made in the Act for referring the application to the Board of Railway Commissioners, who have power to grant the necessary permission, either wholly or in part, or subject to such modifications in plan as may seem necessary, and upon such terms and conditions as may seem to be in the public interest.

Public or private lands, other than public highways, may be acquired by expropriation in the same manner as in the case of lands required for railway purposes, but the Minister of the Interior shall be the sole arbiter as to the area which may be taken without the owner's consent.

CONSTRUCTION OF WORKS.

Immediately upon the receipt of authorization the applicant should proceed with the construction of the works and, unless such authorization is granted between November 1 and May 1 following, is required to commence construction within two months of the date of authorization. If the Minister of the Interior so determines, the works shall be subject to inspection during construction and the cost of such inspection may be assessed upon the applicant.

EXTENSIONS OF TIME FOR CONSTRUCTION.

Should any unforeseen disaster occur to prevent the construction or completion of the works within the time limit, or if for any other reason the minister deems it expedient, he may authorize an extension of time.

LICENSES.

Upon completion of the works an inspection shall be made by the Commissioner or other officer appointed for the purpose. If, after such inspection, the Commissioner is satisfied:—

(*a*) That the works have been completed in accordance with the application;

(*b*) That right of way has been obtained;

(*c*) That agreements have been made and filed for the supply of water for the irrigation of lands which are not the property of the applicant; and

(*d*) That the constructed works are capable of utilizing the required quantity of water,

he shall issue and forward to the department a certificate setting forth the facts. A license is then issued to the applicant for the quantity of water to which he is entitled, based upon the area to be irrigated and the 'duty of water' as fixed by the minister. A fee of $10 is charged for each such license.

PRIORITY OF RIGHT.

The rights of license are determined by the numbers borne by their licenses, and these are assigned on the dates when their applications for water rights are accepted and filed in the office of the Commissioner.* Thus, the right of each applicant is protected against all subsequent applicants, provided he complies with the law and proceeds in good faith to complete his works.

CANCELLATION OF APPLICATIONS OR LICENSES.

When any charge is made to the Minister that any licensee has abandoned, or ceased to use, or is wasting water, such charge may be inquired into and, if found true, the license may be cancelled, if the Minister so orders.

If any authorized works are not completed within the time granted for the purpose, the applicant's rights shall cease, except in so far as they are necessary for the operation of that portion of the works then completed.

The foregoing will suffice to give intending applicants for water rights a fair idea of the necessary procedure, but applicants should carefully study the Irrigation Act and endeavour to familiarize themselves with such of its provisions as may affect their applications. When in doubt they should communicate with the Commissioner, whose office exists primarily for the purpose of affording advice and assistance in such cases.

PROVISIONS *re* COMPANIES.

While this bulletin is published chiefly for the information of individuals who desire to acquire water rights for their own use, it may not be out of place to mention briefly some of the further provisions of the law as it relates to larger projects undertaken usually by incorporated companies. In such cases it is required that the memorial shall, in addition to the other requirements of the Act, set forth the names and places of residence of the directors and officers, the date and purpose of incorporation, the amount of the subscribed and the paid-up capital and the proposed method of raising further funds, if needed. More elaborate plans are also required in the cases of these larger projects, and the law is so framed as to place the government in a position to examine the application not only from an engineering standpoint, but as a business venture as well, and has a tendency to prevent the filing of purely speculative applications.

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* Each licensee is entitled to receive the whole of the supply called for by his license before any licensee whose license bears a higher number has any right to a supply.

Each company obtaining a water license is required to file a return in January of each year giving a comprehensive statement of its operations, including statements of all receipts and disbursements, the mileage of canals and ditches constructed, the number of water users and the acreage actually under irrigation. Copies of all by-laws, regulations, agreements and tariffs must also be filed, and the general form of, and the conditions contained in, agreements for the supply of water, as well as the rate to be charged for water, must be submitted to and approved by the Minister before coming into operation. Thus in addition to a careful scrutiny of each application before acceptance, very complete supervision and control is afterwards provided, in order that the interests of water-users may be adequately protected.

MINOR PROVISIONS.

Among the minor provisions of the Act the following may be mentioned:—

UNIT OF MEASUREMENT OF WATER.

The discharge of one cubit foot of water per second is the unit of measurement of flowing water and the acre foot, *i.e.*, 43,560 cubic feet, is the unit of measurement and quantity.

HIGHWAYS AND BRIDGES.

All public highways shall be kept open for safe and convenient travel during the construction of works under the provisions of the Irrigation Act, and substantial bridges shall be constructed by the applicants before the works are taken into use and such bridges shall always thereafter be maintained by the applicant.

RIGHT OF WAY OVER PRIVATE LANDS.

Plans of right of way required over private lands shall be signed and certified by a Dominion land surveyor and registered in the local land titles office. An additional copy of such plans shall be filed in the Commissioner's office.

STORAGE OF WATER.

The Minister may grant to any licensee permission to store flood water which is not required or being used for any purpose, and if any works for the carriage of water are not being utilized to their full capacity by their owner, the Minister may permit of the use of such works by any licensee for the carriage of such water. If the respective parties fail to agree upon terms the Minister may fix the rate to be paid.

DISPOSAL OF SURPLUS WATER.

Provision is made for requiring any licensee to dispose of any surplus water flowing in his works to any person applying therefor for irrigation purposes and tendering payment in advance.

COMPLAINTS AND INSPECTIONS.

Very complete provision is made for ensuring that companies undertaking to supply water for irrigation purposes shall live up to their obligations. As has already been said, the rates to be charged for water and the general form of the agreements for its supply are subject to the approval of the Minister, and copies of all such agreements must be filed in the office of the Commissioner and in the department. In addi-

tion to this the Minister is empowered to inquire into such complaints as may be brought to his notice, and to take such action as he may consider necessary to remove the cause thereof. Upon failure by any licensee to obey the Minister's order the matter may be referred to the courts.

If, after inspection, it shall be shown to the Minister's satisfaction that any works, either completed or under construction, are injuriously affecting the interests of others, he may order such changes in the works as he may consider necessary for the purpose of removing the cause of complaint, and upon failure of an applicant or licensee to obey such order the Minister shall refer the matter to the courts for summary hearing and such remedial action as the judge or magistrate may consider necessary.

EXPROPRIATION OF WORKS BY THE GOVERNMENT.

The Governor-in-Council is empowered to take over, operate or otherwise dispose of any works authorized under the Irrigation Act, if he deems such action advisable in the public interest, having due regard to the rights of all persons dependent upon such works for water supply. The rate of compensation to be paid for works so taken shall be fixed by arbitration.

POWERS OF MINISTER OF THE INTERIOR.

Under section 54 of the Act the Minister is given general power to make such orders and regulations as may be necessary to carry out the provisions of the Act according to their true intent and to meet any cases which may arise and for which no specific provision is made. Among the more important of the regulations so far made are the following:—

MEASUREMENT OF WATER.

Detailed instructions have been given for ascertaining the volume of water carried by any stream and the measurement of the quantity diverted therefrom, for the establishment of gauge rods in the streams and for standard measuring devices at the headgates of diversion canals and ditches.

DUTY OF WATER.

The ratio between a given quantity of water and the area of land it will irrigate has been fixed at one hundred and fifty acres for each cubic foot of water per second flowing constantly throughout the 'irrigation season,' and all licenses are issued upon this basis.

IRRIGATION SEASON.

The portion of the year during which water may be used for irrigation purposes has been defined as the period from the 1st of May to the 30th September.

LICENSE FEES.

A fee of $10 is charged for each license and a separate license is issued to each person for each stream from which water is diverted. It is not the intention to derive revenue from the issue of licenses, but merely to cover the cost of preparation and issue.

RIGHT OF WAY.

Right of way for irrigation canals or other works in connection therewith is granted free of charge over Dominion lands and such right of way, whether over Dominion or private lands, is limited to a strip of thirty feet in width, exclusive of the width of the ditch, the intention being to limit the grant to such land as may actually be required to give access to the works for purpose of repairs.

FORMS.

The Minister may prescribe the forms to be used in carrying out the provisions of the Act and suitable forms have been adopted where necessary.

SURVEYS, ETC., AND RESERVATION OF LAND.

The Minister is empowered to make such surveys as may be necessary to determine the quantity of water available for use under the provisions of this Act; to establish water gauges for computing the volume of discharge at the various stages of streams; to regulate the extent of diversions so as to secure a beneficial use of the available supply; to reserve from general sale and settlement such Dominion lands as may be required for reservoirs or other purposes in connection with irrigation and to acquire by expropriation any private lands similarly required. Lands so reserved or acquired may be disposed of by sale or lease for utilization under the provisions of the Act.

LEASING OF RESERVOIR SITES.

Suitable sites for reservoirs in connection with any authorized irrigation scheme may be leased for the purpose of water storage, and such leases may be renewed from time to time at the will of the lessee so long as he continues to use the lands for such purposes and complies with all the provisions of the Irrigation Act. Should the lessee cease to use the lands for the purposes mentioned the lease shall be cancelled and the lands will then become available for lease to any other applicant upon similar terms. The annual rental of land for reservoir purposes is at present fixed at twenty-five cents per acre.

SALE OF LAND UNDER IRRIGATION SYSTEM.

In order to encourage settlement and the practice of irrigated farming in southern Alberta and southwestern Saskatchewan, where the average annual rainfall seldom exceeds sixteen inches and often falls considerably below that figure, the government will sell land, within a defined tract in the drier portion of this district, at the rate of three dollars an acre.

DESCRIPTION OF TRACT WITHIN WHICH LAND MAY BE SOLD.

Commencing at the intersection of the north boundary of township 28 with the fourth meridian; thence easterly following the north boundary of townships numbered 28 to the west bank of the south Saskatchewan river; thence southerly along the said west bank of the south Saskatchewan river to a point opposite Aiktow creek; thence across the said south Saskatchewan river to the mouth of the said Aiktow creek; thence up the southerly side of Aiktow creek and across the divide between the said creek and the Qu'Appelle river to the head of the said Qu'Appelle river; thence down the southerly side of the Qu'Appelle river to its intersection with the third meridian; thence southerly along the said third meridian to the north boundary of township 12; thence easterly along the north boundary of townships numbered 12 to the west boundary of range 24; thence southerly along the said west boundary of

range 24, to the north boundary of township 8; thence easterly along the north boundary of townships numbered 8 to the west boundary of range 18; thence southerly along the said west boundary of range 18 to the north boundary of township 4; thence easterly along the north boundary of townships numbered 4 to the west boundary of range 15; thence southerly along the west boundary of range 15 to the international boundary; thence westerly along the said international boundary to the fourth meridian; thence northerly along the fourth meridian to the point of commencement.

CONDITIONS OF SALE.

1. Before any such sale is authorized it shall be shown to the satisfaction of the Minister that the land applied for is irrigable and the water supply sufficient, and that the applicant has applied for a water right and received authorization for the construction of the necessary works.

2. When not exceeding one quarter-section is sold, at least ten acres shall be irrigated, but a sale on such conditions will be made only in cases where the irrigation works are entirely independent of any other works, and where the water is not used upon any other lands.

Where more than one quarter-section is sold, or where land is irrigated on more than one quarter-section, at least fifty per cent of the area sold shall be irrigated.

3. All such sales shall be made at the rate of three dollars ($3.00) per acre, payable in six equal annual instalments, the first of which shall be made within sixty days from the date on which the sale is authorized. Interest at five per cent per annum is charged from the date of sale.

4. It is required that each purchaser shall acquire, by purchase or otherwise, any land (other than Dominion land) upon which any of his works are to be constructed and that he shall transfer title to such land to the Crown. Upon the completion of the irrigation works and the issue of the water license a 'license of occupation' (a conditional patent) will be issued to the purchaser granting him the right to use such land for the operation of his works for so long as his water right remains in effect. This grant may be cancelled should the grantee fail to maintain the irrigation works in good condition. The area required for such right of way is fixed by the Minister of the Interior.

5. Should any purchaser of land under the irrigation system fail to use the irrigation works on such land for the purposes set forth in his plans and memorial within a period of two years from the completion of such works, the ownership of the works shall be forfeited to the Crown.

6. If the works are not completed within the time granted for the purpose, the agreement to sell the land may be cancelled and the amount paid on account thereof may be forfeited to the Crown.

7. In addition to the construction of the irrigation works, the purchaser is required to actually irrigate the land for at least one season before letters patent will be issued to him.

8. Applications to purchase land under these regulations must be made to the agent of Dominion lands for the district in which the lands are situated and should show that the land is required for irrigation. All applications for water rights must be made to the Commissioner of Irrigation at Calgary, Alta., and must be accompanied by a description of the land applied for.

These regulations are framed with a view to the encouragement of irrigated farming, and they impose no onerous conditions upon settlers who in good faith construct and maintain the necessary works and irrigate the land; at the same time the regulations distinctly discourage applications to purchase land for purely speculative purposes.

PART II.—IRRIGATION PRACTICE

BY

J. S. TEMPEST, C.E.,

A farmer considering the advisability of constructing an irrigation system should first consider how he may most cheaply and satisfactorily deliver water to his land, and, secondly, what crops are best adapted to the soil and local conditions. Afterwards, the question of distributing the water over the land to be irrigated must be worked out, and in this he must be governed to some extent by the character of the crops to be grown, as well as by the configuration of the land, as different crops require different methods of applying water, just as they require different forms of cultivation.

While it is undoubtedly true that satisfactory irrigation systems have been devised and constructed by farmers without any knowledge of engineering, it cannot be too strongly emphasized that competent engineering advice is likely to prove economical, rather than the reverse, in the long run. Doubtless farmers can learn by experience to build satisfactory irrigation works, as they are constantly learning to do other new things in this age of more or less scientific agriculture, but the time wasted in experiment and the unsatisfactory results of the first few years represent an expenditure of capital that would, in most cases, repay over and over again the cost of the best obtainable engineering advice. This is particularly the case where the source of water supply is a torrential stream and when a dam is to be constructed.

Irrigation.

Although irrigaton is usually practised only in arid and semi-arid countries, and in the latter, often, only when the seasons are too dry to produce merely fair crops, it is a fact that much benefit and economic gain would result from the practice even where there is a fairly good average rainfall. Rain does not always or even often fall at the time it is needed, while an efficient irrigation scheme is ready to turn on the water at a moment's notice. It has been truly said that irrigation is not a mere substitute for rain but an improvement on it.

SOILS AND SURFACES MOST ADAPTED TO IRRIGATION.

Lands with sandy or gravelly soils or subsoils are the most benefited by irrigation, while clay and heavy soils, being able to retain moisture for a long time, do not suffer as soon from drought and are more easily 'waterlogged' or more readily become 'sour' if not well drained. With good drainage all soils benefit from the judicious application of water, but where the drainage is defective irrigation often does more harm than good. Especially is this the case when alkali is also present.

Swamp lands after undergoing a thorough system of drainage often become good irrigation lands.

Irrigation and drainage should go hand in hand, the former making available plant food in liquid form (the only form assimilable to plant life) and the latter allowing the surplus water to pass away carrying with it, very often, alkali and other

substances injurious to crops. This surplus water percolates through the soil or filters through different strata and may reappear in a neighbouring stream or spring ready to be used again.

Gently sloping surfaces are the best for economical irrigation. Steep hillsides are difficult to work and commonly do not pay for the extra amount of attention required. Very flat land, unless well drained, is apt to be soured by water lying there, coarse wild grasses, by the law of survival of the fittest, occupying the ground against all comers.

SOURCES OF WATER SUPPLY.

Streams are the most common sources of water supply. The smaller streams, however, have the disadvantage of sometimes drying up at the very time they are needed most. The larger streams are more reliable in that respect but are more difficult and expensive to control. When, however, several irrigators can combine in putting in a thoroughly substantial dam and headworks, most economical and satisfactory results may be obtained.

Reservoirs, on account of their reliability, are very desirable when a suitable site can be obtained capable of impounding enough water in winter and flood-time to tide over the demands of the lands to be irrigated.

QUANTITY OF WATER REQUIRED.

The 'duty of water' is two-thirds of a cubic foot per second per one hundred acres.

A stream whose discharge is found to be, say, 2 cubic feet per second would irrigate $(2 \div \frac{2}{3}) \times 100$ acres $= \frac{3}{1} \times \frac{3}{2} \times 100 = 300$ acres.

If it be desired to irrigate 250 acres, a stream would be required with a discharge of $250 \times \frac{2}{3} \div 100 = 1{\cdot}6$ cubic foot per second (or second feet).

The capacity of a reservoir should be at least 2 acre-feet for every acre required to be irrigated; that is, it should hold sufficient water to cover the whole irrigable area with two feet of water. Allowance should also be made for losses from evaporation and seepage.

As there are 43,560 square feet in an acre, each acre would require

$$43{,}560 \times 2 = 87{,}120 \text{ cubic feet of water.}$$

Suppose it is required to irrigate 80 acres from a reservoir, the capacity of the reservoir would have to be

$$87{,}120 \times 80 = 6{,}969{,}600 \text{ cubic feet.}$$

A reservoir with a capacity of 1,000,000 cubic feet would irrigate

$$1{,}000{,}000 \div 87{,}120 = 11{\cdot}47 \text{ acres.}$$

The area of the catchment basin or drainage area required to supply a reservoir for the irrigation of a certain number of acres of land varies considerably. The rainfall and evaporation of the district, the nature of the land and its slope are all factors in determining the amount of water that will reach the reservoir. In Dakota it has been estimated that every 13 or 14 acres of catchment basin will, on an average, supply sufficient water for the irrigation of one acre of land. At this rate every 45 acres of irrigable land requires one square mile of catchment basin to supply its needs.

TO MEASURE DISCHARGE OF SMALL STREAMS.

A simple method of measuring the discharge of small streams is by means of a contracted weir having an opening of from 1 foot to 4 feet according to size of stream.

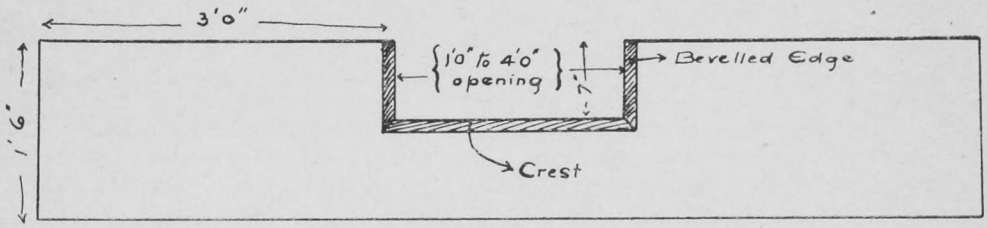

Fig. 1*a*.—Weir Boards for Guaging Streams.

Fig. 1*b*.—Weir Boards in Place.

A dam is built across the stream and in the dam a weir board Fig. 1 (*a*) is placed at right angles to the direction of the stream. Fig. I (*b*) shows the board in place.

The weir board consists of a board about 8 feet long having a rectangular opening from 1 to 4 feet in width cut out. The edges of the opening and the crest are bevelled, leaving one edge sharp. This sharp edge when the board is placed in the dam should be on the up-stream side.

Care should be taken that there is no seepage through the dam and that all the water of the stream passes over the crest.

The head or depth of water above the crest is then ascertained and by referring to table I the discharge is found.

TABLE I (Hoyt & Grover).

DISCHARGES in second-feet, over rectangular sharp-crested weirs with complete end contractions.

HEAD.		LENGTH OF WEIR.					
Inches.	Feet.	12 inches.	18 inches.	24 inches.	30 inches.	36 inches.	48 inches.
¼	·021	0·010	0·015	0·020	0·025	0·030	0·040
½	·042	·028	·042	·056	·071	·085	·113
¾	·062	·051	·077	·103	·129	·155	·207
1	·083	·079	·119	·159	·199	·239	·319
1¼	·104	·110	·166	·222	·278	·334	·445
1½	·125	·144	·217	·291	·364	·438	·585
1¾	·146	·180	·273	·365	·458	·551	·736
2	·167	·219	·332	·446	·559	·672	·899
2¼	·187	·260	·395	·531	·666	·801	1·071
2½	·208	·303	·462	·620	·778	·937	1·253
2¾	·229	·349	·531	·714	·897	1·079	1·444
3	·250	·395	·604	·812	1·020	1·228	1·644
3¼	·271	·444	·679	·913	1·148	1·383	1·852
3½	·292	·494	·756	1·018	1·281	1·543	2·068
3¾	·312	·545	·836	1·127	1·418	1·709	2·291
4	333	·598	·919	1·239	1·559	1·880	2·521
4¼	·354	·652	1·003	1·354	1·705	2·056	2·758
4½	·375	·707	1·090	1·472	1·854	2·237	3.001
4¾	·396	·764	1·178	1·593	2 008	2 422	3·252
5	·417	·821	1·269	1·717	2·164	2·612	3·508
5¼	·437	·879	1·361	1·843	2·324	2·806	3·770
5½	·458	·938	1·455	1·971	2·488	3.005	4·038
5¾	·479	·998	1·550	2·103	2·655	3·207	4·312
6	·500	1·060	1·649	2·237	2·826	3·415	4·592

To accurately ascertain the depth of water above the crest a stake should be driven into the bed of the creek above the weir and by means of a spirit level placed so that the top is exactly on a level with the top of the crest. The depth of water above the top of the stake is the exact head.

WHEN TO IRRIGATE.

The proper time to irrigate varies with the nature of the season and of the crop, as well as the location.

In semi-arid countries it is generally observed that when there is a good, generous rainfall in the late fall of the year, just before winter sets in, growth is generally very promising in the following spring. To irrigate well in the fall, then, may be considered as a good general practice for all crops and for land to be seeded in the spring. When the warm Chinook winds clear off the snow in winter and during the warmer spells in early spring many quick-growing plants and grasses begin to grow, only to be nipped and often killed by the following cold snap. When, however, the ground has been well saturated and is now frozen solid the Chinook and the genial weather has to be of very long duration before the ground is sufficiently thawed out to permit the plant to be affected.

The following list gives approximately the months it has been found expedient to water different crops, making due allowance for variations of season and quantity of rainfall:—

Hay meadows (wild hay, bromus, timothy) should be irrigated in May and in June. The latter irrigation to take place a considerable time before cutting so as to give the grass time to mature as well as to allow the ground to dry sufficiently to ensure the proper curing of the hay.

Wheat and oats should be irrigated once in June and once in July.

Vegetables require water more often than cereals and it may be applied as often as required, probably six or eight times in the season.

Alfalfa or lucerne and clover should be irrigated once in May and once in June.

Perhaps it will not be out of place to quote here a few remarks about alfalfa:—

'Alfalfa is the greatest forage plant the world has ever known, and it should be a special crop with every irrigation farmer. It is a leguminous perennial, and properly belongs to the pea-vine family. Its term of existence has not been authentically established, but it will last the average age of man and instead of depleting the soil, it has a way, through its root nodules, of constantly replenishing the soil with the nitrogenous fertilizing elements of the atmosphere.'—(Wilcox.)

Alfalfa is likely to prove of immense value in Alberta as a regular forage crop and as a soil renovator. It is now being largely grown in the neighbourhood of Lethbridge and has proved successful under irrigation in the foothills where two good crops are grown in the season. In California, under irrigation, it has proved one of the best paying crops a farmer can grow. As six and seven crops can be taken off in that country in a year, farmers have gone to great expense grading large tracts of land so as to be able to irrigate thoroughly, and the expense has proved a most profitable investment.

As soon as a crop has been cut and gathered the ground should be at once irrigated for the next growth.

Construction of Irrigation Works.

DAMS.

In the case of large dams across streams subject to heavy freshets and floods it is sometimes economy to call in an experienced engineer. In dams, more than in any other part of an irrigation scheme, a thoroughly good substantial job pays in the long run. In addition to the extra trouble and expense of maintenance entailed by a temporary, make-shift job, it has the further inconvenience of generally being found wanting just when it is most required.

RESERVOIR DAMS.

Small reservoir dams are generally built of earth, any average earth that is convenient being used. There should be no sod or vegetable matter in the structure and the site should be first ploughed. The best earth mixture for a dam consists of one part clay or gumbo to two or three parts sandy or gravelly soil.

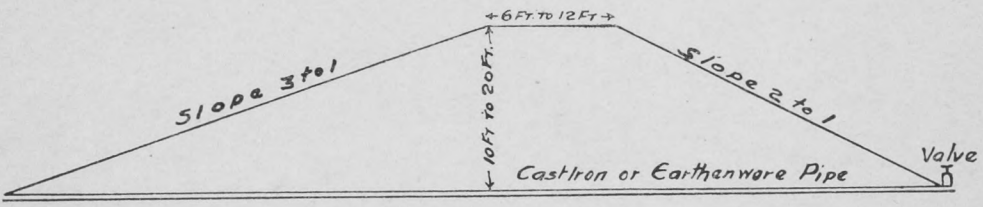

Fig II.

The slope on the up-stream side should be one vertical to three horizontal and on the down-stream side one vertical to two horizontal. The top should vary in width according to the height—from 6 or 8 feet for a 10-foot dam to 12 feet for a 20-foot dam. (See Fig. II.) The dam is made more secure by rip-rapping the upper slope and seeding with grass the lower slope.

The spillway should if possible be placed quite away from the dam so as to prevent damage from erosion and undermining. Where this is not feasible the channel of the spillway should be well protected with rip-rap or planking. The outlet to the ditch should be of cast-iron or earthenware pipe, as wood so quickly decays and it is a very difficult matter to repair a flume through the embankment.

require to be more strongly built on account of the freshets and constant wear of running water. The durability of the headworks depends to a large extent on the choice of location for the dam and headgate and proper provision for waste water.

Sometimes the water of the creek needs be raised only a few feet to reach the headgate and ditch and a ridge of stones and boulders placed across the stream is found sufficient to dam up the water required. Although this is liable to wash out in flood-time and too much seepage occurs in very low water, these two defects are readily remedied at small expense. When, however, the water requires to be raised upwards of four or five feet, earth-and-brush or crib-and-rock dams have to be resorted to.

Fig. III gives cross-section of crib-and-rock dam. The up-stream side of the crib is sheathed with tight planking, while opposite the spillway the crib-work is reinforced as shown on plan. The spillway should be ample—from 10 to 25 feet wide.

Whatever kind of dam is used an apron is indispensable, in order to prevent undermining, except where the bed of the stream is of solid rock.

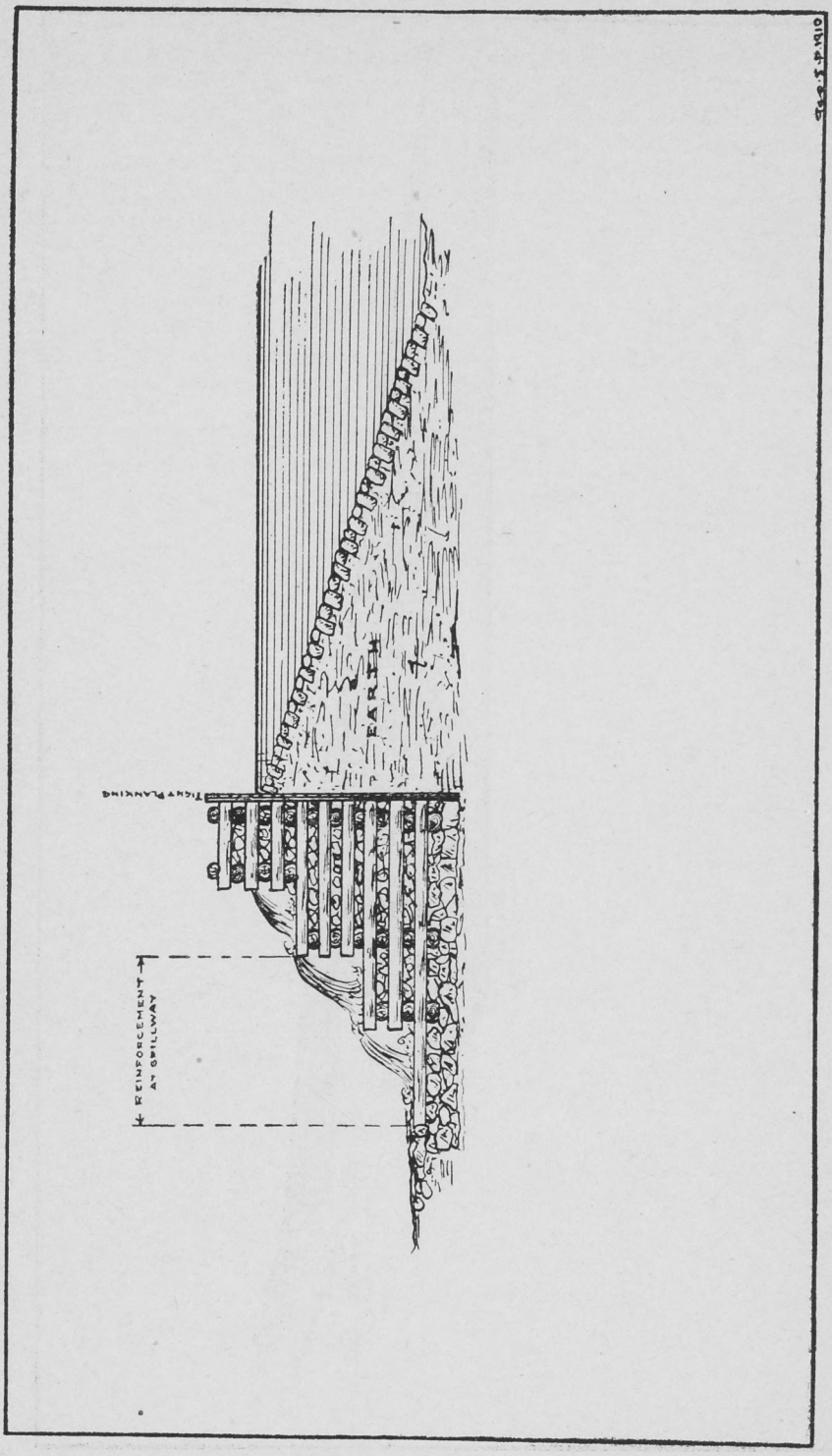

Fig IIIa.—Crib and Rock Dam.

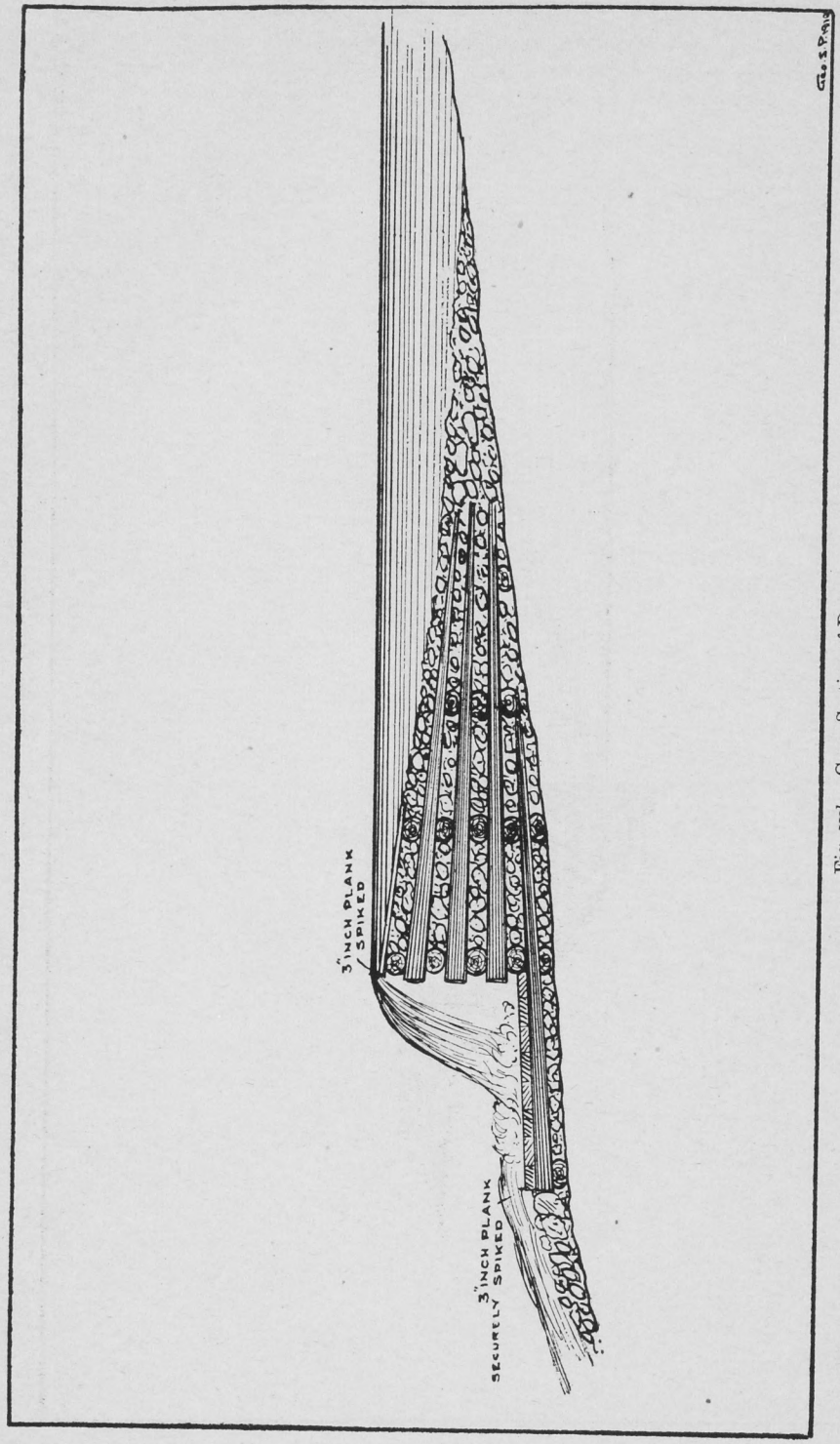

Fig. IIIb.—Cross Section of Dam.

HEADGATE.

In choosing a position for the headgate a careful examination of the stream and of the general direction of the current is necessary. A point in the direction of the current is to be avoided in order to prevent washout and the possibility of the creek abandoning its natural channel in favour of the ditch. On the other hand, backwaters and eddies are apt to silt up the entrance. A point on the shore where the direction of the current is parallel to the banks is as a rule free from danger and can be kept clear from drift-wood and silt.

Figure IV is a view of a headgate that is recommended in the United States. It consists of a box, 6 feet long, 3 feet wide and 3 feet deep with a gate at the end nearest the creek. At both ends are wings and under these, 1½ feet below the floor of the box, are two platforms which are covered with earth to the level of the floor of the box. The wings and submerged platforms are for security in time of flood and to prevent water from working alongside the headgate. Earth should be carefully tamped around the structure.

Lateral headgates may be simpler in design (Fig. IV, *b*). The wings and submerged platforms may be dispensed with. A simple box 18 inches to 2 feet wide and 1 foot to 18 inches deep with a gate is all that is necessary, as a rule.

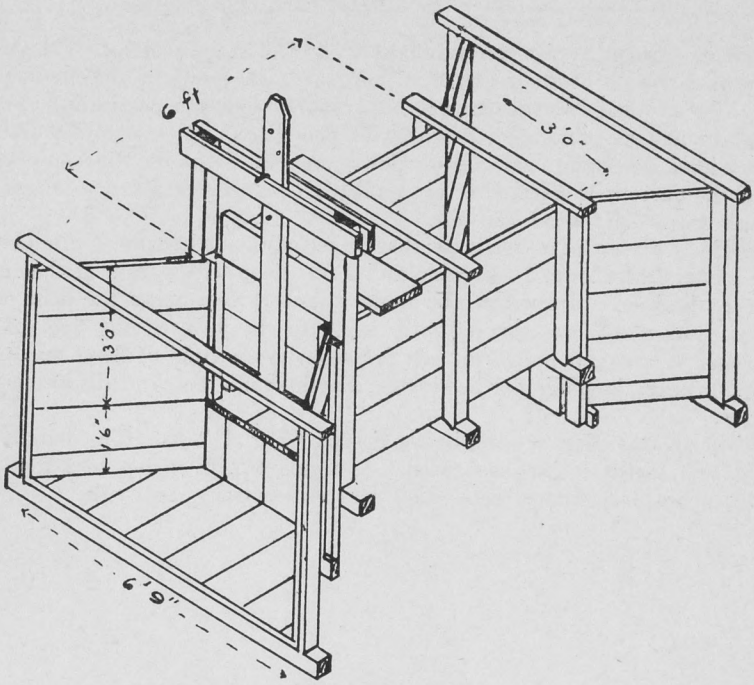

Fig. IV*a*.—View of Headgate.

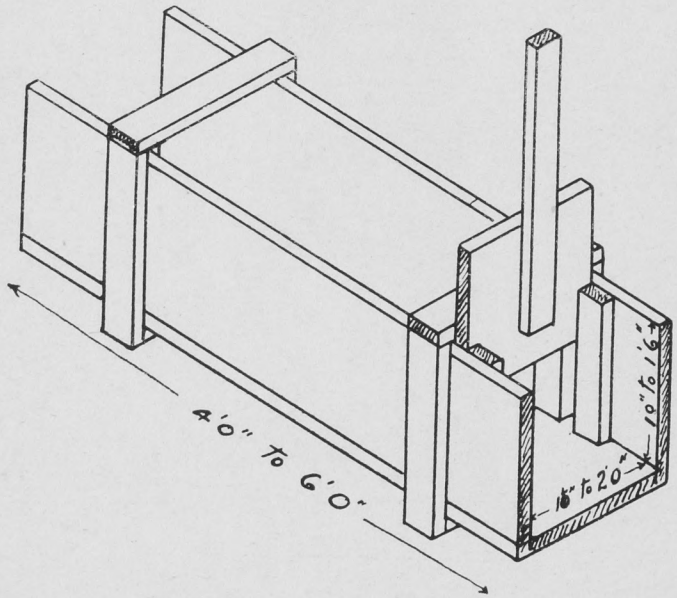

Fig. IV*b*.—View of Lateral Headgate.

DITCH.

The rate of fall of a ditch is of great importance. On the one hand, if the fall is too great the swiftness of the current will wear the sides and cause the banks to cave in. On the other hand, too light a fall would necessitate an increase in the cross-section of the ditch in order to deliver the amount of water required. In addition there would be an unnecessary accumulation of silt on account of the sluggish flow.

The class of material through which a ditch has to run is one factor to be considered. Some classes of material will wash away under a certain velocity of water-flow where others would remain intact.

The following table taken from Kent's Hand Book shows safe velocities through different materials:—

TABLE II.—SAFE VELOCITY OF WATER IN DITCHES.

Soft brown earth	0·3 feet per sec.
Soft loam	0·6 " "
Pure sand	1·1 " "
Gravel	2·6 " "
Sandy soil, 15 per cent clay	1·2 " "
Sandy soil, 40 per cent clay	1·8 " "
Loamy soil, 65 per cent clay	3·0 " "
Clay loam, 85 per cent clay	4·8 " "
Agricultural clay, 95 per cent clay	6·2 " "
Clay	7·2 " "

Knowing, then, the class of material we have to deal with and the safe velocity, also the quantity of water per second required to irrigate a certain extent of land, we next consider the natural fall of the ground. If it is falling rapidly then we must make the velocity as great as the material will stand. If on the other hand the land is very flat we must give a very slight fall, yet one that will supply the quantity of water required without too expensive a ditch.

The following table from Farmers' Bulletin No. 158 (United States Department of Agriculture) shows the velocities and discharges of ditches with different grades:—

Table III.

Velocities and Discharges of Ditches with different Grades.

Dimensions of Ditch.			Grade of Ditch, 1 ft. per mile.		Grade of Ditch, 2 ft. per mile.		Grade of Ditch, 3 ft. per mile.		Grade of Ditch, 4 ft. per mile.		Grade of Ditch, 5 ft. per mile.		Grade of Ditch, 6 ft. per mile.		Grade of Ditch, 8 ft. per mile.		Grade of Ditch, 10 ft. per mile.	
Top width.	Bottom width.	Depth.	Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.
Feet.	Feet.	Feet.	Feet per section.	Cubic feet per section.	Feet per section.	Cubic feet per section.	Feet per section.	Cubic feet per section.	Feet per section.	Cubic feet per section.	Feet per section.	Cubic feet per section.	Feet per section.	Cubic feet per section.	Feet per section.	Cubic feet per section.	Feet per section.	Cubic feet. per section.
1·5	1·0	0·5	0·34	0·21	0·50	0·31	0·61	0·38	0·71	0·44	0·81	0·51	0·91	0·57	1·04	0·65	1·17	1·04
3·0	2·0	1·0	·48	1·21	·72	1·81	·87	2·27	1·01	2·53	1·16	2·89	1·29	3·23	1·48	3·70	1·66	7·26
4·5	3·0	1·5	·67	3·77	1·00	5·60	1·20	6·72	1·39	7·84	1·59	8·97	1·78	9·97	2·03	11·42	2·28	12·85
6·0	4·0	2·0	·85	8·50	1·24	12·40	1·49	14·90	1·74	17·40	1·99	19·90	2·21	22·10	2·53	25·30	2·85	28·50

As an example, suppose it is required to irrigate a certain tract of land, say 65 acres in extent, and let the soil be sandy soil with about 15 per cent clay.

From table II we find the safe velocity for soil of this nature is 1·2 feet per second; that is, we must not give the water in the ditch a greater velocity than this or there will be more or less wear.

Now suppose we want to give the ditch as much fall as possible on account of the nature of land.

Sixty-five acres will require $^{65}/_{100} \times {}^{2}/_{3} = {}^{130}/_{300} = 0{\cdot}433$ cubic feet per second.*

Referring now to table III we find that a ditch with top width of 1·5 feet, bottom 1·0 foot and depth of 0·5 foot and with a gradient of 10 feet per mile would have a velocity of 1·17 feet per second and would carry 1·04 cubic feet per second. Thus such a ditch would have sufficient capacity and yet be within the safe limit.

If, on the other hand, on account of the land being nearly level it were desired to have the least fall allowable, we find from table III that a ditch 3 feet top width, 2 feet bottom width and 1 foot deep would convey the water required at a safe velocity were the gradient only 1 foot per mile. As will be seen from table III there are other gradients and dimensions of ditch that will suit the same discharge per second having also safe velocities, and it only remains for the intending irrigator to use a little judgment as to the most adaptable and convenient grade and dimension.

Methods of Applying Water to the Land.

There are numerous methods of applying water to the land for the purpose of irrigation, but only those methods will here be considered that are adaptable to the requirements and conditions which obtain in Alberta and Saskatchewan:—

1. The most common and simplest method is that of running the water over the land from the main and lateral ditches. This method is sometimes called 'flowing.' Openings are made in the ditch and the water allowed to flow out over the land. Where the surface of the ground falls very rapidly there is danger of its being cut up into gullies, but by increasing the number of openings in the ditch and allowing only small streams to run from each this difficulty may be avoided. As the water spreads further and further over the land, more and more is absorbed until a point is reached where its influence is no longer felt. At this point there should be a lateral ditch carrying a fresh supply of water to carry the process of irrigation to a lower belt of land. In gently sloping surfaces these laterals require to be nearer together than in steeper ground.

2. Irrigation by submersion or flooding is best adapted to flat or nearly flat lands. It consists in covering tracts of land with water and allowing it to remain until the soil is sufficiently saturated. In addition to the ditches other works are necessary when this method is adopted. If the ground is rough and uneven it is necessary to prepare the surface with plough, road scraper, crowder and even drag scraper. Then to hold the water on a given tract on land a ridge of earth must be thrown up around its edges.

These ridges will have to be increased in number and placed nearer together the more slope there is to the ground. When the ground has been prepared water is let into the basins from the ditch.

TABLE IV.—Approximate Grade Equivalents.

Grade of	1	foot	per	mile	=	$\frac{1}{4}$	inches	per	100 feet	= $1\frac{1}{8}$ inches per 500 feet.
"	2	"	"		=	$\frac{3}{8}$	"	"		= $2\frac{1}{4}$ " "
"	3	"	"		=	$\frac{3}{4}$	"	"		= $3\frac{1}{2}$ " "
"	4	"	"		=	$\frac{7}{8}$	"	"		= $4\frac{1}{2}$ " "
"	5	"	"		=	$1\frac{1}{8}$	"	"		= $5\frac{5}{8}$ " "
"	6	"	"		=	$1\frac{3}{8}$	"	"		= $6\frac{3}{4}$ " "
"	8	"	"		=	$1\frac{5}{8}$	"	"		= 8 " "
"	10	"	"		=	$2\frac{1}{4}$	"	"		= $11\frac{1}{4}$ " "

* See under 'Quantity of Water Required,' page 14.

TABLE V.

VOLUME of material to be removed per mile in the excavation of ditches of different dimensions.

DIMENSIONS OF DITCH.			VOLUME OF MATERIAL TO BE MOVED PER MILE.
Top Width.	Bottom Width.	Depth.	
Feet.	Feet.	Feet.	Cubic Yards.
1·5	1·0	0·5	122
3·0	2·0	1·0	489
4·5	3·0	1·5	1,100
6·0	4·0	2·0	1,956